radionuclide inhaled or ingested via each pertinent route of exposure (e.g., ingestion of contaminated drinking water, direct ingestion of contaminated soil, ingestion of contaminated produce/milk/meat). Measured or predicted external exposure rates should be presented, along with the exposure time, frequency, and duration. In the absence of measured exposure rates, the concentration of each radionuclide in soil is needed to estimate the risk from the external pathway using slope factors. When present, estimates of radiation surface contamination also should be presented by radiation type (alpha, beta, gamma).

III. TOXICITY ASSESSMENT

Q19. What is the mechanism of radiation damage?

A. Radiation emitted by radioactive substances can transfer sufficient localized energy to atoms to remove electrons from the electric field of their nucleus (ionization). In living tissue, this energy transfer can produce chemically reactive ions or free radicals, destroy cellular constituents, and damage DNA. Irreparable DNA damage is thought to be a major factor in carcinogenesis. [While ionizing radiation may also cause other detrimental health impacts, only radiogenic cancer risk is normally considered in CERCLA risk assessments (see Q24).]

The type of ionizing radiation emitted by a particular radionuclide depends upon the exact nature of the nuclear transformation, and may include emission of alpha particles, beta particles (electrons or positrons), and neutrons; each of these transformations may be accompanied by emission of photons (gamma radiation or x-rays). Each type of radiation differs in its physical characteristics and in its ability to inflict damage to biological tissue. For purposes of radiation risk estimates, the various types of radiation are often categorized as low linear energy transfer (LET) radiation (photons and electrons) and high-LET radiations (alpha particles and neutrons).

Ionizing radiation can cause deleterious effects on biological tissues only when the energy released during radioactive decay is absorbed in tissue. The average energy imparted by ionizing radiation per unit mass of tissue is called the "absorbed dose". The SI unit of absorbed dose is the joule per kilogram, also assigned the special name the Gray (1 Gy = 1 joule/kg); the conventional unit of absorbed dose is the rad (1 rad = 100 ergs/g = 0.01 Gy).

Q20. What are radionuclide slope factors?

A. EPA has developed slope factors for estimating incremental cancer risks resulting from exposure to radionuclides via inhalation, ingestion, and external exposure pathways. Slope factors for radionuclides represent the probability of cancer incidence as a result of a unit exposure to a given radionuclide averaged over a lifetime. It is the age-averaged lifetime excess cancer incident rate per unit intake (or unit exposure for external exposure pathway) of a radionuclide (U.S. EPA 1989a).

Current radionuclide slope factors incorporate the age- and gender-specific radiogenic cancer risk models from *Estimating Radiogenic Cancer Risks* (U.S. EPA, 1994b). Age-specific estimates of absorbed dose rate are used, where available, for internal exposure pathways, whereas dose estimates for external exposure are taken directly from *Federal Guidance Report No. 12* (U.S. EPA 1993b). Population mortality statistics and baseline cancer rates reflect the U.S. population of 1989-1991 (1979-1981 for slope factors derived prior to 1998). Detailed information on the derivation and application of risk coefficients and radionuclide slope factors is presented in *Radiation Exposure and Risk Assessment Manual (RERAM)* (U.S. EPA, 1996, 1998h). Agency-recommended slope factors for radionuclides (as well as nonradioactive carcinogens) are published in EPA's *Health Effects Assessment Summary Tables* (HEAST) (U.S. EPA, 1998e). EPA plans to revise the HEAST tables based on information in *Federal Guidance Report No. 13: Health Risks from Low-Level Environmental Exposure to Radionuclides* (U.S. EPA 1998g).

Q21. What are radionuclide dose conversion factors?

A. Dose conversion factors (DCFs), or "dose coefficients", for a given radionuclide represent the dose equivalent per unit intake (i.e., ingestion or inhalation) or external exposure of that radionuclide. These DCFs are used to convert a radionuclide concentration in soil, air, water, or foodstuffs to a radiation dose. DCFs may be specified for specific body organs or tissues of interest, or as a weighted sum of individual organ dose, termed the effective dose equivalent (these quantities are discussed further in Q21). These DCFs may be multiplied by the total activity of each radionuclide inhaled or ingested per year, or the external exposure concentration to which a receptor may be exposed, to estimate the dose equivalent to the receptor.

EPA-approved DCFs for inhalation and ingestion exposure are published in *Federal Guidance Report No. 11* (U.S. EPA, 1988b). EPA-approved DCFs for external exposure are published in *Federal Guidance Report No. 12* (U.S. EPA, 1993b). Both compilations provide DCF values for a reference adult only, but it is anticipated that future revisions will include values for other age groups.

Q22. What is dose equivalent, effective dose equivalent, and related quantities?

As discussed in Q18, different types of radiation have differing effectiveness in transferring their energy to living tissue. Since it is often desirable to compare doses from different types of radiation, the quantity "dose equivalent"

has been defined as a measure of the energy absorbed by living tissues, adjusted for the relative biological effectiveness of the type of radiation present. The SI unit for dose equivalent is the sievert (Sv) and the conventional unit is the rem (1 rem = 0.01 Sv). For computation of dose equivalent, the absorbed dose is multiplied by Quality Factor (Q) or radiation weighting factor (w_R); these values range from 1 for photons and electrons to 10 for neutrons to 20 for alpha particles (i.e., for an equal amount of energy absorbed, an alpha particle will inflict approximately 20 times more damage to biological tissue than that inflicted by a beta particle or gamma ray). Internally deposited (i.e., inhaled or ingested) radionuclides may be deposited in various organs and tissues long after initial deposition. The "committed dose equivalent" is defined as the integrated dose equivalent that will be received by an individual during a 50-year period (based on occupational exposure) following the intake. By contrast, external radiation exposure contribute to dose only as long as the receptor is present within the external radiation field.

When exposed to equal doses of radiation, different organs and tissues in the human body will exhibit different cancer induction rates. The quantity "effective dose equivalent" was developed by the International Commission on Radiological Protection (ICRP) to account for these differences and to normalize radiation doses and effects on a whole body basis for regulation of occupational exposure. The effective dose equivalent is computed as a weighted sum of organ-specific dose equivalent values, with weighting factors specified by the ICRP (ICRP 1977, 1979). The effective dose equivalent is equal to that dose equivalent, delivered at a uniform whole-body rate, that corresponds to the same number (but possibly dissimilar distribution) of fatal stochastic health effects as the particular combination of organ dose equivalents.

Q23. What is the critical organ approach to dose limitation?

A. Critical organ standards developed by EPA and NRC usually consist of a combination of whole body and critical organ dose limits, such as 25 mrem/yr to the whole body, 75 mrem/yr to the thyroid, and 25 mrem/yr to any critical organ other than the thyroid. When these standards were adopted, dose was calculated and controlled for each organ in the body and uniform radiation of the "whole body." The "critical organ" was the organ that received the most dose for the radionuclide concerned. With the adoption of the dose equivalent concept, the dose to each organ is weighted according to the effect of the radiation on the overall system (person). The new system allows for one value of dose equivalent to be assigned as a limit, which is protective of the entire system. The critical organ approach required individual limits for each organ based on the effect of radiation on that organ.

It should be noted that although most critical organ standards include 25 mrem/yr or higher (75 mrem/yr) dose limits, these critical organ standards are not comparable to 25 mrem/yr effective dose equivalent standards or guidance. EPA's determination that the 25 mrem/yr dose level found in NRC's decommissioning standard and various guidance should not be used to establish cleanup levels at CERCLA sites does not apply to critical organ standards.

Q24. How should radionuclide slope factors and dose conversion factors be used?

A. **EPA recommends that radionuclide slope factors be used to estimate the excess cancer risk resulting from exposure to radionuclides at radiologically contaminated sites for comparison with EPA's target risk range (i.e., 10^{-4} to 10^{-6} lifetime excess cancer risk).** The incremental risk is calculated by multiplying estimates of the lifetime intake via inhalation and ingestion of each radionuclide of concern, and the duration and concentration in environmental media to which the receptor is exposed via the external exposure pathway, by the appropriate slope factor values for that exposure pathway and radionuclide. Additional information on the use of radionuclide slope factors and their underlying assumptions, which introduce significant uncertainties, is provided in the Radiation Exposure and Risk Assessment Manual (RERAM) (U.S. EPA 1996a, 1999b).

Estimates of cancer risk from radionuclide exposures may also be computed by multiplying the effective dose equivalent computed using the DCFs by a risk-per-dose factor. EPA recommends that this method **not** be used at CERCLA sites to estimate risks for PRGs or cleanup levels, and estimates computed using this method may tend to inaccurately estimate potential risks, with the magnitude of discrepancy dependent on the dominant radionuclides and exposure pathways for the site-specific conditions. These differences can be attributed to factors such as the consideration of competing mortality risks and age-dependent radiation risk models in the development of the slope factors, different distributions of relative weights assigned to individual organ risks in the two methods, and differences in dosimetric and toxicological assumptions. Some key differences in the two methods are summarized in Table 2.

Due to these factors, no simple and direct conversion between radiation dose and radiogenic cancer risk is available. Given the differing dosimetric and radio-toxicological characteristics of different radionuclides, as reflected in the DCFs and slope factors, respectively, a given dose from one radionuclide via a given exposure pathway may present a much greater cancer risk than the same dose from another radionuclide and/or exposure pathway. Therefore, any conversion between dose and risk now must be performed on a radionuclide- and pathway-specific basis.

The primary use of DCFs should generally be to compute doses resulting from site-related exposures for comparison with radiation protection standards and dose limits (see Q31-32) that are determined to be ARARs or TBCs. This is accomplished by multiplying the exposure estimates produced through the exposure assessment (i.e., the intake of each radionuclide of concern via inhalation and ingestion, and the duration of exposure and concentration of each radionuclide of concern in environmental media for external exposure) by the appropriate DCF values for that exposure pathway and radionuclide. Unlike excess cancer risk, which represents cumulative lifetime exposure, dose estimates are typically expressed in terms of annual exposure (e.g., the effective dose equivalent resulting from exposure during a one-year period, mrem/year).

Unless otherwise stated in the standard, DCFs from *Federal Guidance Report No. 11* (U.S. EPA, 1988b) and *Federal Guidance Report No. 12* (U.S. EPA, 1993b) should be used for complying with ARARs based on effective dose equivalent, while DCFs from ICRP 2 should be used when complying with ARARs based on the critical organ approach.

Q25. In addition to cancer, should the potential teratogenic and genetic effects of radiation exposures be considered?

A. Biological effects associated with exposure to ionizing radiation in the environment may include carcinogenicity (i.e., induction of cancer), mutagenicity (i.e., induction of mutations in somatic or reproductive cells, including genetic effects), and teratogenicity (i.e., effects on the growth and development of an embryo or fetus). Agency guidance (U.S. EPA, 1989a, 1994b) indicates that the radiogenic cancer risk is normally assumed to be limiting for risk assessments at Superfund sites, and evaluation of teratogenic and genetic effects is not required. Similarly, consideration of acute effects normally is not required, since these effects occur only at doses much higher than normally associated with environmental exposures.

Q26. Should chemical toxicity of radionuclides be considered?

A. At Superfund radiation sites, EPA generally evaluates potential human health risks based on the radiotoxicity (i.e., the adverse health effects caused by ionizing radiation), rather than on the chemical toxicity, of each radionuclide present. Uranium, in soluble form, is a kidney toxin at mass concentrations slightly above background levels, and is the only radionuclide for which the chemical toxicity has been identified to be comparable to or greater than the radiotoxicity, and for which a reference dose (RfD) has been established to evaluate chemical toxicity. For radioisotopes of uranium, both effects (radiogenic cancer risk and chemical toxicity) should be considered.

IV. RISK CHARACTERIZATION

Q27. How should radionuclide risks be estimated?

A. Risks from radionuclide exposures should be estimated in a manner analogous to that used for chemical contaminants. That is the estimates of intakes by inhalation and ingestion and the external exposure over the period of exposure estimated for the land use (e.g., 30 years residential, 25 years commercial/industrial) from the exposure assessment should be coupled with the appropriate slope factors for each radionuclide and exposure pathway. Only excess cancer risk should be considered for most radionuclides (except for uranium as discussed in Q25). The total incremental lifetime cancer risk attributed to radiation exposure is estimated as the sum of the risks from all radionuclides in all exposure pathways.

Q28. Should radionuclide and chemical risks be combined?

A. **Yes. Excess cancer risk from both radionuclides and chemical carcinogens should be summed to provide an estimate of the combined risk presented by all carcinogenic contaminants as specified in OSWER directive 9200.4-18 (U.S. EPA 1997a).** An exception would be cases in which a person reasonably can not be exposed to both chemical and radiological carcinogens. Similarly, the chemical toxicity from uranium should be combined with that of other site-related contaminants. As recommended in RAGS Part A (U.S. EPA 1989a), risk estimates for radionuclides and chemical contaminants also should be tabulated and presented separately in the risk characterization report.

There are generally several differences between slope factors for radionuclides and chemicals. However, similar differences also occur between different chemical slope factors. In the absence of additional information, it is reasonable to assume that excess cancer risks are additive for purposes of evaluating the total incremental cancer risk associated with a contaminated site.

Q29 How should risk characterization results for radionuclides be presented?

A. Results should be presented according to the standardized reporting format presented in *RAGS* Part D (U.S. EPA, 1998a). However, specific guidance for radionuclides (i.e., the Radionuclides Worksheet) is not yet available.

EPA guidance for risk characterization (U.S. EPA, 1992e) indicates that four descriptors of risk are generally needed for a full characterization of risk: (1) central tendency (e.g., median, mean) estimate of individual risk; (2) high-end estimate (e.g., 95th percentile) of individual risk; (3) risk to important subgroups (e.g., children) of the population, such as highly exposed or highly susceptible groups or individuals, if known; and (4) population risk. The reasonable maximum exposure (RME) estimate of individ-

ual risk typically presented in Superfund risk assessments represents a measure of the high-end individual exposure and risk. While the RME estimate remains the primary scenario for risk management decisions, additional risk descriptors may be included to describe site risks more fully.

Q30. Should the collective risk to populations be estimated along with that to individual receptors?

A. Risk to potential individual receptors is the primary measure of protectiveness under the CERCLA process (i.e., the target range of 10^{-6} to 10^{-4} lifetime excess cancer risk to the RME receptor). As noted in Q28, however, Agency guidance (U.S. EPA, 1992e) also indicates that the collective risk to the potentially exposed population and to important subgroups of the population also should be evaluated where possible. Consideration of population risk provides additional input to risk management decisions; such considerations may be either qualitative or quantitative depending on the availability of data and the magnitude of projected population risk.

Q31. How should uncertainty in estimates of radiation risk be addressed in the risk characterization report?

A. Consideration of uncertainty in estimates of risks from potential exposure to radioactive materials at CERCLA sites is essential for informed risk management decisions. *RAGS* and subsequent guidance (U.S. EPA, 1992e, 1995b) stress the importance of a thorough presentation of the uncertainties, limitations, and assumptions that underlay estimates of risk. Either qualitative or quantitative evaluation may be appropriate, depending on the availability of data and the magnitude of predicted risk. In either case, the evaluation should address both uncertainty (i.e., "the lack of knowledge about specific factors, parameters, or models") and variability (i.e., "observed differences attributable to true heterogeneity or diversity in a population or exposure parameter"). Estimates of potential risk should include both central tendency estimates (median, mean) and high-end estimates (e.g., RME or 95th percentile).

Table 2. Comparison of Radiation Risk Estimation Methodologies: Slope Factors vs Effective Dose Equivalent

Parameter	Slope Factor Approach	Effective Dose Equivalent x Risk Factor Approach
Competing Risks	• Persons dying from competing causes of death (e.g., disease, accidents) are not considered susceptible to radiogenic cancer. • Probability of dying at a particular age from competing risks is considered based on the mortality rate from all causes at that age in the 1989-1991 (previously 1979-1981) U.S. population.	• Competing risks not considered.
Risk Models	• Age-dependent and gender-dependent risk models for 14 cancer sites are considered individually and integrated into the slope factor estimate.	• Risk estimate averaged over all ages, sexes, and cancer sites.
Genetic Risk	• Genetic risk is not considered in the slope factor estimates; however, ovary is considered as a potential cancer site.	• Effective dose equivalent (EDE) value includes genetic risk component.
Dose Estimates	• Low-LET and high-LET dose estimates considered separately for each target organ.	• Dose-equivalent includes both low-LET and high-LET radiation, multiplied by appropriate Quality Factors.
RBE for high-LET (alpha) radiation	• 20 for most sites (8 prior to 1994) • 10 for breast (8 prior to 1994) • 1 for leukemia (1.117 prior to 1994)	• 20 (all sites)
Organs Considered	• Estimates of absorbed dose to 16 target organs/tissues considered for 13 specific cancer sites plus residual cancers.	• EDE (ICRP, 1979) considers dose estimates to 6 specific target organs plus remainder (weighted average of 5 other organs).
Lung Dose Definition	• Absorbed dose used to estimate lung cancer risk computed as weighted sum of dose to tracheobronchial region (80%) and pulmonary lung (20%).	• Average dose to total lung (mass weighted sum of doses to the tracheobronchial region, pulmonary region, and plumonary lymph nodes).
Integration Period	• Variable length (depending on organ-specific risk models and consideration of competing risks) not to exceed 110 years.	• Fixed integration period of 50 years typically considered.
Dosimetric / Metabolic Models	• Metabolic models and parameters for dose estimates follow recent recommendations of the ICRP series of documents on age-specific dosimetry (ICRP, 1989, 1993, 1995a, 1995b), where available; previous estimates based primarily on ICRP 30 (ICRP, 1979).	• Typically employ ICRP Publication 30 (ICRP, 1979) models and parameter for radionuclide uptake, distribution, and retention.

For both chemical carcinogens and radionuclides, extrapolation from high dose and dose rate exposure is generally required to estimate risks of low-level exposures. This extrapolation typically constitutes the greatest source of uncertainty. For chemical carcinogens, additional uncertainty may be introduced due to extrapolation of animal data to humans. Slope factors for both radionuclides and chemicals are used to estimate incremental cancer risk, which typically represents a small increment over a relatively high baseline incidence. Other sources of uncertainty may include that associated with instrumentation and measurements used to characterize the nature and extent of radionuclides of concern, and the parameters used to characterize potential exposures of current and future receptors (e.g., intake rates, frequency of exposure).

Probabilistic Risk Assessment (PRA) may be used to provide quantitative estimates of the uncertainties in the risk assessment. However, probabilistic estimates of risk should always be presented as a supplement to - not instead of - the deterministic (i.e., point estimate) methods outlined in *RAGS Part A*. A tiered approach is often useful, with the rigor of the analysis dependent on the magnitude of predicted risk. Factors to be considered in conducting a probabilistic analysis typically should include the sensitivity of parameters, the correlation or dependencies between parameters, and the distributions of parameter values and model estimates. Detailed guidance on this topic is provided in *Use of Probabilistic Techniques (Including Monte Carlo Analysis) in Risk Assessment* (U.S. EPA 1997c) and *Guiding Principles for Monte Carlo Analysis* (U.S. EPA 1997d).

Q32. When should a dose assessment be performed?

OSWER Directive 9200.4-18 (U.S. EPA 1997a) specifies that cleanup levels for radioactive contamination at CERCLA sites should be established as they would for any chemical that poses an unacceptable risk and the risks should be characterized in standard Agency risk language consistent with CERCLA guidance. **Cleanup levels not based on an ARAR should be based on the carcinogenic risk range (generally 10^{-4} to 10^{-6}, with 10^{-6} as the point of departure and 1 x 10^{-6} used for PRGs) and expressed in terms of risk (# x $10^{-\#}$).** While the upper end of the risk range is not a discrete line at 1 x 10^{-4}, EPA generally uses 1 x 10^{-4} in making risk management decisions. A specific risk estimate around 10^{-4} may be considered acceptable if based on site-specific circumstances. For further discussion of how EPA uses the risk range, see OSWER Directive 9355.0-30, Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions (U.S. EPA 1991d). In general, dose assessment used as a method to assess risk is not recommended at CERCLA sites.

Please note that the references to 15 mrem/yr in OSWER Directive 9200.4-18 are intended as guidance for the evaluation of potential ARARs and TBCs, and should not be used as a TBC for establishing 15 mrem/yr cleanup levels at CERCLA sites. **At CERCLA sites dose assessments should generally not be performed to assess risks or to establish cleanup levels** except to show compliance with an ARAR that requires a dose assessment (e.g., 40 CFR 61 Subparts H and I, and 10 CFR 61.41).

Q33 How and when should exposure rate be used to estimate radionuclide risks?

As discussed previously (see Q24 and Q27), EPA recommends that estimates of radiation risk should be derived using slope factors, in a manner analogous to that used for chemical contaminants. However, there may be circumstances where it is desirable to **also** consider estimates of risk based on direct exposure rate measurements of penetrating radiation. Instances where it may be beneficial to also use direct measurements for assessing risk from external exposure to penetrating radiation include:

- During early site assessment efforts when the site manager is attempting to communicate the relative risk posed by areas containing elevated levels of radiation,
- As a real-time method for indicating that remedial objectives are being met during the conduct of the response action. The use of exposure rate measurements during the conduct of the response actions may not decrease the need for a final status survey.
- When risk estimates developed during a risk assessment may underestimate the level of risk posed by radionuclides. An example of this situation would be where the source of the radiation is highly irregular (inside a contaminated structure) instead of being an infinite plane, which is the standard assumption used during risk assessments.

When developing risk estimates under any of these situations, risk factors from "Estimating Radiogenic Cancer Risks, EPA 402-R-93-076" or HEAST plus shape & area factor, should be used in conjunction with the measured dose rate to develop a risk estimate for external exposure to penetrating radiation.

Direct radiation exposure rate measurements may provide important indications of radiation risks at a site, particularly during early investigations, when these may be the first data available. However, such data may only reflect a subset of the radionuclides and exposure pathways of potential concern (e.g., only external exposure from gamma-emitting radionuclides in near-surface soil), and may present an incomplete picture of site risks (e.g., risk from internal exposures, or potential increased future risks from radionuclides in subsurface soils). In most cases, more accurate estimation of radiation risks will require additional

site characterization data, including concentrations of all radionuclides of concern in all pertinent environmental media. The principal benefits of exposure rate measurements is the speed and convenience of analysis, and the elimination of potential modeling uncertainties. However, these data should be used in conjunction with, rather than instead of, characterization data of radionuclides concentrations in environmental media to obtain a complete picture of potential site-related risks.

Q34. What radiation standards may be applicable or relevant and appropriate requirements (ARARs)?

A. In some cases, cleanup levels may be derived based on compliance with ARARs. Attachment A "Likely Federal Radiation Applicable or Relevant and Appropriate Requirements (ARARs)" of OSWER Directive 9200.4-18 (U.S. EPA 1997a) provides information regarding the circumstances in which federal standards that have often been selected as ARARs may be either applicable or relevant and appropriate for particular site-specific conditions. **It should be noted that the Agency has determined that the NRC decommissioning requirements (e.g., 25, 100 mrem/yr dose limits) under 10 CFR 20 Subpart E should generally not be used to establish cleanup levels under CERCLA**, even when these regulations are ARARs. OSWER Directive 9200.4-25, *Use of Soil Cleanup Criteria in 40 CFR Part 192 as Remediation Goals for CERCLA Sites* (U.S. EPA 1998c), provides more detailed discussion on the use of the concentration limits for radium and/or thorium in subsurface soils.

V. ECOLOGICAL ASSESSMENTS

Q35. What guidance is available for conducting ecological risk assessments.

A. OSWER Directive 9285.7-25, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (U.S. EPA June 1997) is intended to facilitate defensible and appropriately-scaled site-specific ecological risk assessments at CERCLA sites. This guidance is not intended to dictate the scale, complexity, protocols, data needs, or investigation methods for such assessments. Professional judgement is required to apply the process outlined in this guidance to ecological risk assessments at specific sites.

VI. BACKGROUND CONTAMINATION

Q36. How should background levels of radiation be addressed?

A. Background radiation levels on a specific site will generally be determined as background levels are determined for other contaminants, on a radionuclide-specific basis when the same constituents are found in on-site samples as well as in background samples. The levels of each constituent in background are compared to that on site-related contaminant to determine its impact, if any. Background is generally measured only for those radionuclides that are contaminants of concern and is compared on a radionuclide specific basis to determine cleanup levels. For example, background levels for radium-226 and radon-222 would generally not be evaluated at a site if those radionuclides were not site-related contaminants.

In certain situations background levels of a site-related contaminant may equal or exceed PRGs established for a site. In these situations background and site-related levels of radiation will be addressed as they are for other contaminants at CERCLA sites. For further information regarding background, see section "Background Contamination" in OSWER Directive 9200.4-18 (U.S. EPA 1997a).

WHERE TO GO FOR FURTHER INFORMATION

Attachment 1 provides a bibliography of selected EPA documents related to radiation risk assessment. Readers should periodically consult the EPA Headquarters and Regional Superfund and Radiation Program Offices for updates on current guidances and for copies of new documents. Copies of many of the documents listed in Attachment 1 are available to the public for a fee from the National Technical Information Service (NTIS) at (703) 605-6000 or (800) 553-6847. Many documents are also available from EPA on the Internet.

Radiation and radioactive materials pose special hazards and require specialized detection instrumentation, techniques and safety precautions. EPA strongly encourages RPMs and risk assessors to consult with individuals trained and experienced in radiation measurements and protection. Such individuals include health physicists and radiochemists who can provide additional assistance in designing and executing radionuclide sampling and analysis plans and interpreting radioanalytical results.

The subject matter specialists for this fact sheet are Dr. Kung-Wei Yeh of ORIA and Stuart Walker of OERR. General questions about this fact sheet should be directed to 1-800-424-9346.

REFERENCES

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